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ABSTRACT

Ways in which school facility planners, managers, and others can guard against the potential indoor air quality (IAQ) problems presented by paint are covered in this bulletin. It opens with an overview of paint formulations and the functional quality of different paints, paying special attention to the volatile organic compounds present in some paints. Contaminant sources such as the solvents used in paints and the emission rates of various paints are also detailed. The different factors that affect comfort and health, such as accumulated exposure, and what the standards and regulations are regarding human exposure are also covered. Administrators can use several control methods to enhance the IAQ in schools through careful paint selection, which includes checking the age of the paint, never using exterior paint inside a building, and ensuring that the paint is "rated" for the surface(s) to be painted. Communicating with those involved in the project; paint selection; developing a work plan; having adequate ventilation; and clean-up, proper disposal, and storage are control methods that are emphasized. (Contains three figures and one table.) (RJM)

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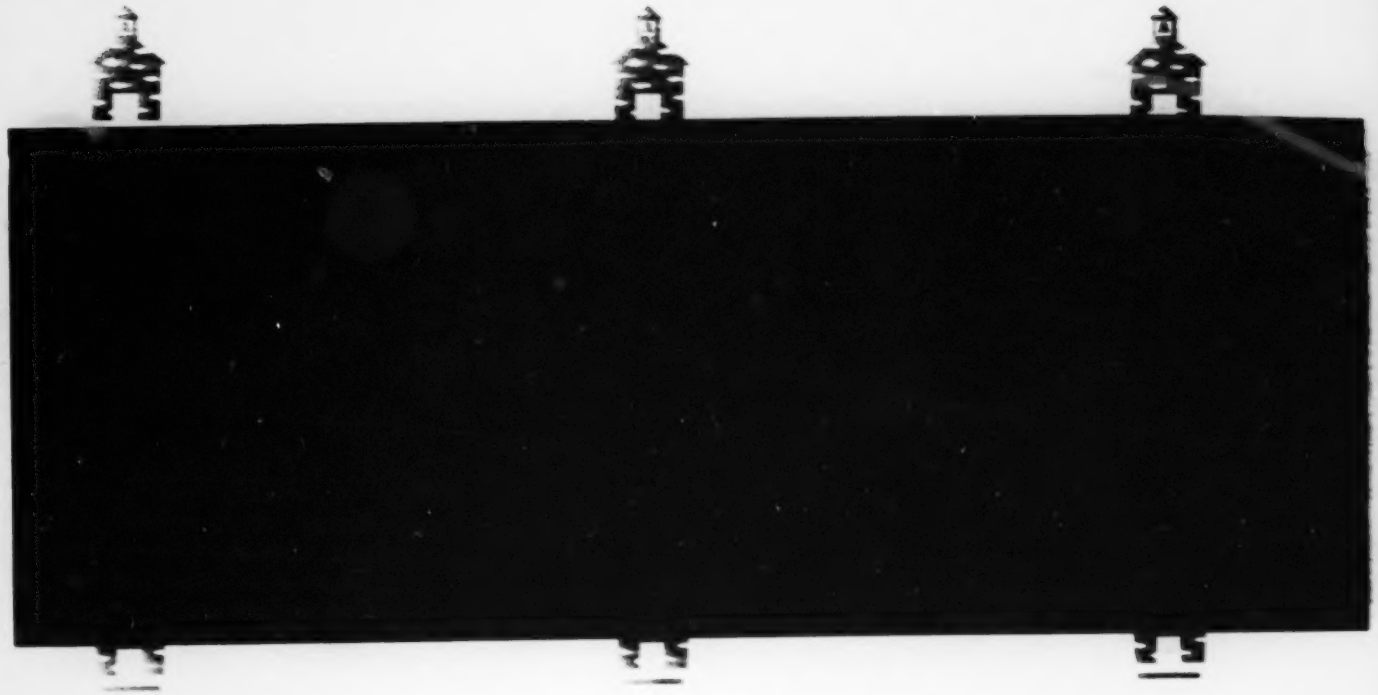

INTERIOR PAINTING AND INDOOR AIR QUALITY IN SCHOOLS

Prepared By
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March 1994
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Introduction

Paint, when applied as an interior architectural coating, enhances aesthetics, allows for improved maintenance, and protects interior surfaces from the damaging effects of various environmental factors. Painting is generally seen as a straight-forward, simple process requiring relatively few decisions in selecting and applying the product(s). However, paint formulation and technology is quite complex, with the potential to introduce a myriad of chemicals into the indoor environment. In addition to the paints themselves, other products such as strippers, primers, and thinners containing additional chemicals must often be used. These chemicals may present comfort and health problems to exposed individuals due to aerosolization and evaporation during and for some time after application, and from exposure to dusts or particulates generated from the mechanical disturbance of the cured materials.

The purpose of this bulletin is first to provide school facility planners, managers and others with an overview of some of the potential indoor air quality (IAQ) problems presented by paints. Secondly, it presents the various regulatory standards, professional guidelines, and work practices that will enable school personnel to make more informed judgments regarding the selection of paints, application procedures, and communication techniques to minimize the potential for adverse impacts on students, school personnel, and others.

Paint Formulations

Paints can generally be described based on the solvent systems utilized in their formulations. The two primary types of interior paints are alkyd (hydrocarbon solvent based, generally higher volatile organic compound (VOC) content) and latex (water based, generally lower VOC content).

Most formulations consist of various blends of pigments, solvents, film-formers (resins), and additives. These terms are described below.

Figure 1. Materials Found in Paint Formulations

- Pigments — very fine powders incorporated into paints to provide color and opacity (hiding power)
- Solvents — materials used to dissolve or suspend film-formers, thereby providing a consistency suitable for application
- Film-formers — nonvolatile binders that bind the pigment particles together and bind the paint coating to the substrate
- Additives — substances added in small quantities to the paint formulation that contribute to the ease of manufacture, packaging stability, ease of application, quality or appearance. Major classes include plasticizers, surface-active agents, flow modifiers, driers, anti-skinning agents, and biocides.

Figure 1 provides an overview of the many materials that may be found in paint formulations.

Functional Quality

Paint manufacturers have developed coatings with excellent functional qualities that the market has come to expect. These qualities include ease of application and maintenance, appearance, and durability.

To some degree, the indoor air quality concerns attributed to paints are directly related to the amount of VOCs present in the formulations. However, the reduction of total VOCs does not guarantee that there will be less impact on indoor air quality. Some chemicals are toxic at very low levels.

Typical ranges of VOC content for some paint types on the market today are presented in Table 1.

In response to new environmental regulatory initiatives to reduce the amounts of VOCs released to the atmosphere numerous paint manu-

Table 1:
Typical VOC Content of Paints

Paint Type	g/L*
Latex Flat	50-150
Latex Semi-Gloss	125-190
Latex Hi-Gloss Acrylic	250
Alkyd	300-400

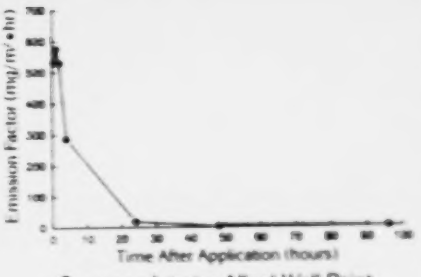
*grams of VOC per liter of paint, g/L

facturers formulated "flat" products with VOC content in the range of 30-50 g/L using the same resin systems designed for higher VOC content. However, durability is a recognized problem with these formulations. Also, these paints tend to be thicker and more difficult to apply, are more susceptible to fading, and less resistant to mildew.

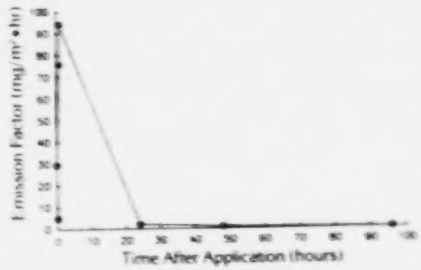
The coatings industry has recently developed some new resins which are compatible with low-VOC and no-VOC paint formulations while at the same time retaining the functional qualities consumers have come to expect. The first of these resins has recently entered the marketplace through certain paint lines.

In response to the growing number of environmentally conscious individuals, several companies are advertising paints formulated from "natural" products. Natural paints should not be viewed as being free of hazardous constituents, but, in general, are formulated from substances thought to be less harmful. They may not perform as well as conventional paints, may require more expertise to apply, may require more coats and a longer drying time, and typically offer a narrower range of colors at higher costs.

"Natural" paints include casein (a milk solid) paint and plant-based paints. Casein paint is a solid white coating that can be mixed with organic pigments to obtain a wide variety of colors. However, mold growth problems have been reported and the paint is only lightly washable and cannot be scrubbed or washed with abrasive soaps. Plant-based paints are formulated using natural resins, oils, beeswax, pigments, and fillers. These plant-based paints are not widely available and their increased cost would generally prohibit them from being considered for use within a school system.



Common Interior Alkyd Wall Paint



Common Interior Latex Wall Paint

Figure 2. TVOC Emission Profile (Source: Air Quality Sciences, Inc.)

Contaminant Sources

The solvent systems used in paints, and sometimes the additives, may present IAQ problems due to the aerosolization and evaporation of volatile solvents and additives during and, for a period of time, after application. The purpose of paint solvent is to dissolve or suspend the film-formers in a mixture suitable for application. Once applied, the solvent evaporates so that the film (coating) may form. The majority of this evaporation takes place relatively quickly (within about 48 hours), and highly concentrated airborne levels of the compounds can be attained. Poorly ventilated areas, spaces that have higher painted surface area to volume ratios, and areas where paint is applied using techniques that enhance aerosolization (roller and spray) can have increased airborne levels.

Figure 2 compares the emission rates, over time, of total volatile organic compounds (TVOC) from a latex paint to that of an alkyd paint. These graphs, while utilizing actual laboratory data, are illustrative only of the general differences between the two paint types. Paints can vary greatly in their specific emission rates.

After drying, paint presents a long-term source of potential contaminants. The contaminants of concern after drying are typically associated with the heavy metals used in the pigments. Exposure can occur if the film is degraded in some manner and fails to adhere to the surface. This degradation may be due to natural chipping or peeling associated with dampness and age or intentional mechanical means such as sanding and scraping. Degradation processes may generate small particles of paint dust or deposit larger particles or chips on the floor that can be ground under foot. Very small particles of paint dust can become airborne and present an inhalation hazard or be ingested by transferring dust to the mouth with contaminated hands. This hand-to-mouth exposure is of special concern for young children and others who have more contact with the floor and are prone to placing their hands and fingers in their mouths. Eating and drinking in areas contaminated with this dust also increases the potential for ingestion.

Paint strippers, often used in renovations, are a related source of indoor air pollution. Conventional paint strippers contain methylene chloride, which is toxic and a suspected carcinogen. Several new strippers have been developed that do not contain this chemical and claim to be low-emitting. These products take longer to work (from one hour to overnight) but are reported to be effective. However, just because a stripper does not contain methylene chloride it should not be presumed to be non-toxic. The components of all products should be reviewed for safety, health, and environmental concerns.

It is important to emphasize that the presence of "contamination" or a

source of contaminants does not, by itself, create a health problem. The contaminants have to be taken in and absorbed by the human body in sufficient quantity and within certain time constraints before health effects can be observed. This is the concept of "dose and effect." What constitutes a toxic dose can vary widely from one substance to another. For example, lead exhibits toxic effects at relatively low doses, while iron is an essential nutrient and exerts toxic effects only at very high doses.

Comfort and Health Effects

Exposures to indoor air pollutants and their ensuing health effects are generally classified as acute or chronic. Acute exposure to a chemical is usually measured in minutes or in some cases, seconds. Acute health effects are those manifested almost immediately (e.g., irritation of mucous membranes, cough). Chronic exposure to a chemical refers to a repeated exposure over a long duration, usually measured in days, months, or years. Chronic health effects are those that develop and persist over time (e.g., cancers, liver and kidney effects) and, therefore, their appearance may not coincide with exposure to the causative agent(s).

There is no clear division between physical discomfort and the onset of health symptoms, or between the perception of odors and irritant effects. However, as odors become stronger, more and more people will experience olfactory irritation which will eventually be manifested in IAQ symptoms. Individuals' responses to odors vary widely. Some people are extremely sensitive to certain odors and will find almost any level objectionable and discomforting.

The most common adverse health responses associated with poor IAQ are subtle and not always immediately linked to air contamination. The symptoms reported are often non-specific rather than clearly defined illnesses. Typical IAQ symptoms include headache, fatigue, shortness of breath, sinus congestion, cough, sneezing, dizziness, nausea, and eye, nose, throat, and skin irritation.

As shown in Figure 1, there are multiple types of hydrocarbon based solvents used in paints, each associated with certain general health effects. Most solvents affect the central nervous system to some extent, acting as depressants and anesthetics. Others have "target organs" such as the liver, kidney, brain, and blood as well as the reproductive organs. Many solvents also act as irritants to the eyes, nose, and throat.

Potential health effects associated with paints are also attributable to the heavy metals found in the pigments and biocides. These include antimony, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, and nickel. Most of the metals that are of particular health concern bind strongly to human tissues. Consequently the body does not excrete them readily and accumulations may reach toxic doses over time even if daily intakes are small.

The health effects associated with the solvents and metals have been observed, primarily, in workers exposed to relatively high concentrations in the industrial environment. The occupational exposure limits discussed below, are meant to protect a healthy adult work force against, to a large extent, obvious and fully developed health effects. Without proper procedures those individuals in schools adjacent to areas being painted may be exposed to levels approaching those of workers. Workers, however, may be exposed day after day, while others are subject to decreasing levels as the paint dries. "Background" indoor air exposures are 2-3 orders of magnitude lower than these occupational exposure limits. At this time, there is not enough information available to characterize the response of the human population to these lower levels.

Standards and Regulations

There are few airborne exposure standards specifically established for children in schools. Human exposure guidelines for a number of air pollutants have, however, been established in regulations or recommended for other environments by various governmental agencies and professional organizations. Differences between guidelines usually stem from the assumptions about the population each guideline is intended to protect. For example, air contaminant limits for the workplace are comparatively high since they are intended to protect a relatively healthy, adult industrial workforce, are not intended to protect the more sensitive individuals, and assume little or no exposure to the contaminant beyond the normal 40-hour work week. Workplace exposure limits are appropriate for evaluating exposures experienced by the painting crews.

The Occupational Safety and Health Administration (OSHA) regulates workplace exposure to many of the components found in paints through the use of Permissible Exposure Limits (PELs). The National Institute for Occupational Safety and Health (NIOSH) performs health effects research and studies, then makes recommendations to OSHA for new regulations based on their work. The OSHA PELs and NIOSH recommendations are contained in Department of Health and Human Services (NIOSH) Publication No. 90-117, "Pocket Guide to Chemical Hazards," available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

The American Conference of Governmental Industrial Hygienists (ACGIH) annually publishes a list of Threshold Limit Values (TLVs) to be used as guidelines for the control of potential health hazards in the workplace, including those associated with paint components. The original OSHA PELs were based on the 1968 list of TLVs. TLV booklets are available from the ACGIH, Technical Information Office, 1330 Kemper Meadow Drive, Cincinnati, OH 45240.

Other organizations and regulatory bodies have developed approaches for assessing non-industrial workplace exposures. These are summarized below.

- ASHRAE Standard 62-1989 summarizes IAQ exposure guidelines and standards used in the U.S. and Canada and consensus guidelines published by the World Health Organization. Appendix C of this standard recommends that the TLVs be divided by 10 before using them to evaluate IAQ exposures. Information regarding ASHRAE Standards is available from ASHRAE, 1791 Tullie Circle, N.E., Atlanta, GA 30329.

- Many states are developing air toxics regulations or guidelines. Most of these states are applying safety factors to workplace exposure limits to develop ambient (outdoor) exposure limits. The safety factors used vary from state to state and range in magnitude from 42 to 100. These limits are designed to protect the more susceptible members of the general population (asthmatics, etc.) and, therefore, may be more applicable for evaluating the indoor environment where protection of similar populations is desired. However, the scientific basis for the safety factor must be understood and matched with the toxic hazard presented by each chemical.

The EPA is developing a national VOC regulatory program under the authority of the 1990 Clean Air Act Amendments aimed at reducing total VOC emissions from architectural and industrial maintenance coatings. The purpose of this regulation is to lower ozone levels in the outside air.

A regulatory negotiation committee was formed that included numerous paint and coating industry representatives. The committee has developed a tentative understanding with the EPA regarding the concepts of a regulatory framework and VOC emission reduction goals. The EPA must now develop a draft rule which must be proposed, public hearings held, and comments received before a final rule is promulgated. Although manufacturers will be reducing total VOCs in paint, this does not guarantee that these paints will have less of an impact on IAQ. The negotiations do not address the health hazards of individual VOCs in paint. Some chemicals are toxic at very low levels.

Good management of painting projects can minimize IAQ problems.

Control Methods

Good management of painting projects can minimize IAQ problems. The management process starts with the selection of the paint and proceeds through coordinating with and notifying affected parties, preparing the work space, using proper application techniques, incorporating good ventilation, and finally the proper cleaning of the area, disposing of wastes, and storing the remaining paint. Each of these management areas is described in more detail below.

A. Paint Selection

1. The age of the paint should always be checked before using. The sale and distribution of interior latex paint containing mercury compounds ceased as of September 30, 1991. Interior latex paints containing mercury have caused mercury poisoning of children. The federal government strictly controlled the lead content of paints in 1977. It is not expected that school facilities or contractors would use pre-1977 products, but it is possible that older interior paints could still be available that contain higher levels of mercury compounds. Recycled paints should also be avoided since they may contain mercury compounds.

2. Exterior paints should not be used for interior work. Mercury compounds and other biocides have been found in exterior formulations at concentrations that may pose a serious hazard if used indoors.

3. Ensure that the product is "rated" for the surface(s) to be painted. For example, different paint types are recommended for use on different architectural/building materials, and only paints that form an elastic coating should be used on surfaces that are subject to temperature extremes, such as on radiators. If the paint does not bond well with the surface, it will lose its adhesion and be subject to cracking and peeling thus presenting a potential particulate hazard.

4. Obtain a Material Safety Data Sheet (MSDS) and other information on the characteristics of each paint purchased or under consideration. Schools should ask manufacturers to submit the following:

- The material contents of the product
- Identification and quantified amounts of substances that are listed on either: (a) the International Agency for Research on Cancer List of Chemical Carcinogens; (b) the Carcinogen List of the National Toxicology Program; or (c) the Reproductive Toxin List of the Catalog of Teratogenic Agents.

Larger school systems, or a consortium of school systems, may wish to consider asking manufacturers to supply additional data on their paints when bidding on significant paint quantities and/or contract time periods. For example, a school system may identify a limited number of high usage paints and require bidders to submit data on total VOCs emitted ($mg/m^2 \cdot hr$) within 48 hours of application, using a specified testing protocol. The EPA is currently developing a standardized protocol for quantifying total and specific VOC emissions from paints. The State of Washington has adopted emission rate standards that manufacturers, including paint manufacturers, must not exceed for state construction projects. Insistence by building owners on receiving this information will advance

the development of product-by-product testing and standardized testing methods for a wide array of products.

5. Evaluate the potential for contaminant build-up within the painted space, factoring together the amount in the paint, volatility, and how well the space will be ventilated. It would be beneficial to obtain assistance from safety and health support personnel to evaluate MSDSs of the paints, and work practices used by the maintenance staff (perhaps on an annual basis).

6. After consideration of all of the above, select the paint with the least hazard potential that will provide acceptable functional qualities (e.g., ease of application and maintenance, appearance, durability) within budgetary constraints.

B. Communication

A strong, proactive approach in this area will head off many potential problems. Personnel who are familiar with the proposed work should meet with the affected school's principal as early as possible in the planning process. The principal should assist in the scheduling and ensure that any special concerns ("sensitive" individuals, problem areas) are communicated to the maintenance staff/paint foreman. The principal should be provided with paint MSDSs and accompanying information as to how the paints were selected and scheduling details. All affected individuals should then be informed of the planned activities. This information should include an overview of how each group (staff, teachers, students) will be affected (disrupting of normal routines) and a summary of the steps taken to minimize potential problems (selecting appropriate paints, scheduling, isolating areas, relocating students, etc.). All affected parties should be encouraged to provide their input and express any concerns. The MSDSs should also be made available to anyone at a convenient location.

This information can be given to school personnel during regularly scheduled meetings. A special effort must be made to ensure that all parents are included in the process. This may be accomplished by sending an official memorandum, or a less formal "flyer" to the students' parents. This communication should describe how their children's routine will be impacted, steps the school has taken to minimize impacts, point(s) of contact for the parents to ask questions and express concerns, and where MSDSs are available.

C. Work Plan

Ideally, work should be scheduled during unoccupied periods, or periods of least occupancy. This is especially important for those tasks that will produce the most dust, odor, VOC emissions, and/or emissions of more potentially toxic components. School systems may wish to consider changing the work schedule of the painting crew(s) to accommodate these "off-hour" recommendations on a non-overtime basis. Large projects should be scheduled during the summer vacation months or other breaks. It is unrealistic, however, to expect surfaces to be maintained and painted only when a building is unoccupied.

Great care must be used if the work will include the removal of old paint. Chemical strippers are hazardous for workers, give off strong vapors, and generate large quantities of hazardous waste. Also, some strippers soak into the base material and may serve as a source of emissions for some period of time. Manufacturer's directions and recommendations for ventilation and use of personal protective equipment should be strictly adhered to whenever using chemical strippers. Some heat guns are powerful enough to volatilize components of the paint being removed. Whenever possible, the items to be stripped (doors, windows, trim, etc.) should be removed from the school and sent to an off-site facility that is set up to safely perform the stripping. In some cases it may be more expedient and cost-effective to simply replace the substrate (e.g., trim) than to remove the old paint, particularly when dealing with lead-based paint.

If the school was constructed prior to approximately 1980, it is important to determine if lead-based paint is present. It should be determined if any lead paint studies/surveys have been performed by reputable inspectors and laboratories. Surface preparation techniques generating dust (sanding, scraping) must not take place until confirmation is received that the work area does not contain lead paint. Strict health and safety regulatory requirements must be implemented when disturbing lead paint. Paint crews must be properly trained to work with lead-based paint. In Maryland, for example, enabling legislation regarding licensure of abatement personnel and lead testing personnel has been enacted into law, with regulation to go into effect in 1994.

Work preparation should include removing, or otherwise protecting, as many items of furniture, supplies, and other articles as possible from the work area. Many of these items, especially fabrics, may adsorb vapors and then slowly release them back to the room air after reoccupancy of the space.

Except for touch-up and very small paint jobs, it is recommended that areas be ventilated during painting and for a minimum of 48 hours after application.

Consideration should be given to the construction of barriers (e.g., walls or curtains of plastic sheeting) to help isolate portions of larger areas (e.g., gymnasiums, open classrooms) and minimize the distribution of dust and other pollutants.

D. Ventilation

Except for touch-up and very small paint jobs, it is recommended that areas be ventilated during painting and for a minimum of 48 hours after

application. Ventilation beyond the 48 hour minimum is desirable, if practical. While emissions over time vary among products, the emission rate curves presented in Figure 2 for typical paints demonstrates that the vast majority of VOCs are emitted within 48 hours of application. The air from the areas being painted must be ventilated directly to the outside, and no portion should be recirculated. This can be accomplished by ensuring that the heating, ventilating, and air conditioning (HVAC) system is providing maximum outdoor air, and by using local exhaust ventilation.

Recirculation of air from the work area should be prevented because ductwork and plenums may have materials (e.g., duct liners, spray-on fireproofing, ceiling tiles) that are potentially capable of adsorption and re-release of VOCs. Dust may also be generated (especially from surface preparation-scraping, sanding) that contain heavy metals. These dusts may accumulate within the system and be dispersed into occupied spaces.

A local exhaust system may be as simple as setting up floor fans and/or window fans to ventilate directly outside if the room has operable windows or doors to the outside. In the absence of direct access to the outside, portable ventilation units can be used that have flexible ducting attached so that exhaust air can be ducted to the nearest available window or door. If this method is used, the door through which the exhaust air is exiting the room must be sealed so that a negative pressure is set up within the room and makeup (dilution) air is provided from another location, preferably at a point where the dilution air sweeps across as much of the freshly painted surface(s) as possible (see Figure 3).

Finally, the method of application must also be considered. Brush application will have the least impact on IAQ, while the use of roller and spray techniques can increase emissions through aerosolization and, therefore, the potential

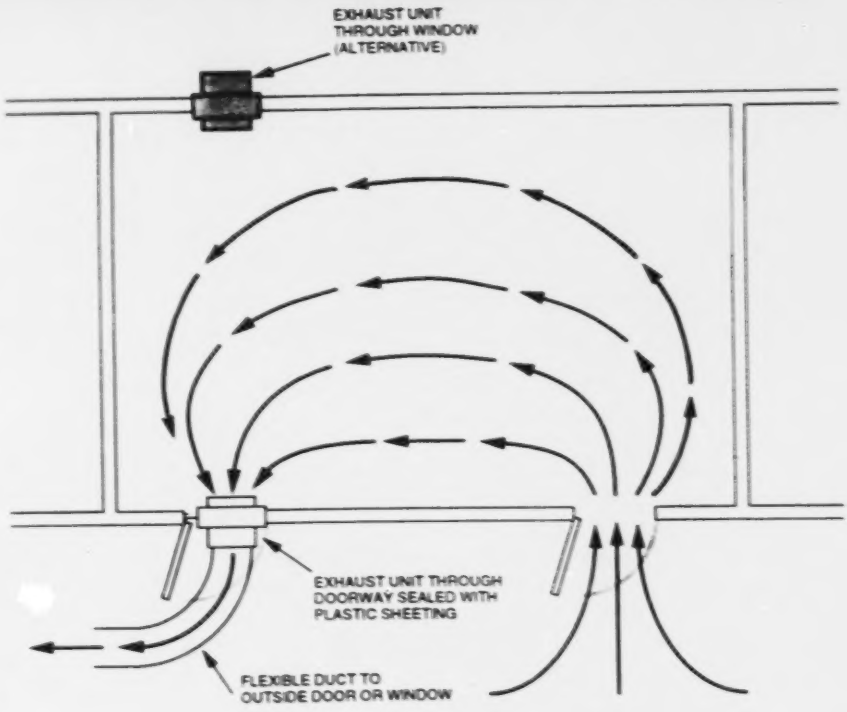

EXHAUST UNIT THROUGH WINDOW (ALTERNATIVE)
EXHAUST UNIT THROUGH DOORWAY SEALED WITH PLASTIC SHEETING
FLEXIBLE DUCT TO OUTSIDE DOOR OR WINDOW

Figure 3. Ventilation of Freshly Painted Room with 2 Doors (plan)

for problems. Paints applied by spraying tend to require higher solvent fractions to allow for smoother flow. The paint exits the sprayer nozzle as a particulate (aerosol) and the fraction that does not adhere to the surface being coated (overspray) can be dispersed over a wide area. If spray application is used it is very important that good application techniques and the manufacturer's equipment operation guidelines are followed explicitly to reduce overspray. Appropriate respiratory and eye protection should also be used by each painter using a sprayer.

E. Clean-Up, Disposal, and Storage

Some practical steps that can reduce the emissions from painting projects include putting lids back on paint containers every time paint is poured out, and not pouring too much at one time (as in a tray for roller application). Significant amounts of VOCs can be emitted from the surface of an uncovered container of paint. Therefore, whenever painting is ceased for a period of time (end of day, long break, lunch), all paints in open trays, etc. should be poured back into original containers and sealed.

If thinners are used, it is important to not only ensure that the thinner is always in a closed container, but that any rags that have been used with thinner to wipe up paint are stored in sealed containers.

Some paints are classified as "flammable liquids" under federal regulations. These paints must be stored in a specifically constructed safety cabinet. The paint label and MSDS should be consulted for appropriate storage precautions.

It is important to wipe down all surfaces with a wet cloth as soon as practical after completing all dust-generating work activities within an area. These activities are typically associated with surface preparation operations such as scraping and sanding. This will keep the dust from

spreading further within the building and greatly reduce the amount of dust remaining after the job that may become resuspended in the air. Dust may be vacuumed up only if the vacuum is equipped with a sealed compartment for the collection bag and a high efficiency particulate air (HEPA) filter. Non-HEPA filtered vacuums will only spread contamination since the filtration system is not designed to trap small particles.

Finally, it is critical that, upon completion of the job, the disposition of wastes and left-over paint be carefully considered. It may be appropriate to retain some or all of the left-over paint for some period of time. If so, ensure that all containers are tightly sealed and stored properly. Paint should never be stored in HVAC mechanical rooms. Inevitably, there will be some leakage of VOCs from paint containers, therefore, it is important that the storage area be located such that the air is not drawn into occupied areas. Leakage of VOCs may occur if the storage area is not vented to the outside, if the storage area is located within the school and is under "positive pressure" with respect to the adjoining area, or if the vapors are exhausted close to the air intake. Therefore, it is not recommended that paints be stored within the school in quantities greater than deemed necessary for efficient functioning.

For excess paints, it is important to first consider recycle/reuse options. The paints could be turned back to a central collection/storage facility within the school system for reuse, or donated to a non-profit organization that can use the paints to assist those in need. These organizations are becoming increasingly common and make good use of all types of "excess" building materials.

All paint containers with residual liquid must be disposed of as hazardous waste per the U.S. Environmental Protection Agency's Resource Conservation and Recovery Act regulations. Only dry containers can be placed in municipal landfills.

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